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Dynamic Control Theory: A Behavioral Modeling Approach to Demand Forecasting amongst Office Workers Engaged in a Competition on Energy Shifting

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Abstract : Many grids are increasing the share of renewable energy in their generation mix, which is causing the energy generation to become less controllable. Buildings, which consume nearly 33% of all energy, are a key target for demand response: i.e., mechanisms for demand to meet supply. Understanding the behavior of office workers is a start towards developing demand response for one sector of building technology. The literature notes that dynamic computational modeling can be predictive of individual action, especially given that occupant behavior is traditionally abstracted from demand forecasting. Recent work founded on Social Cognitive Theory (SCT) has provided a promising conceptual basis for modeling behavior, personal states, and environment using control theoretic principles. Here, an adapted linear dynamical system of latent states and exogenous inputs is proposed to simulate energy demand amongst office workers engaged in a social energy shifting game. The energy shifting competition is implemented in an office in Singapore that is connected to a minigrid of buildings with a consistent 'price signal.' This signal is translated into a 'points signal' by a reinforcement learning (RL) algorithm to influence participant energy use. The dynamic model functions at the intersection of the points signals, baseline energy consumption trends, and SCT behavioral inputs to simulate future outcomes. This study endeavors to analyze how the dynamic model trains an RL agent and, subsequently, the degree of accuracy to which load deferability can be simulated. The results offer a generalizable behavioral model for energy competitions that provides the framework for further research on transfer learning for RL, and more broadly— transactive control.

Keywords : energy demand forecasting, social cognitive behavioral modeling, social game, transfer learning
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